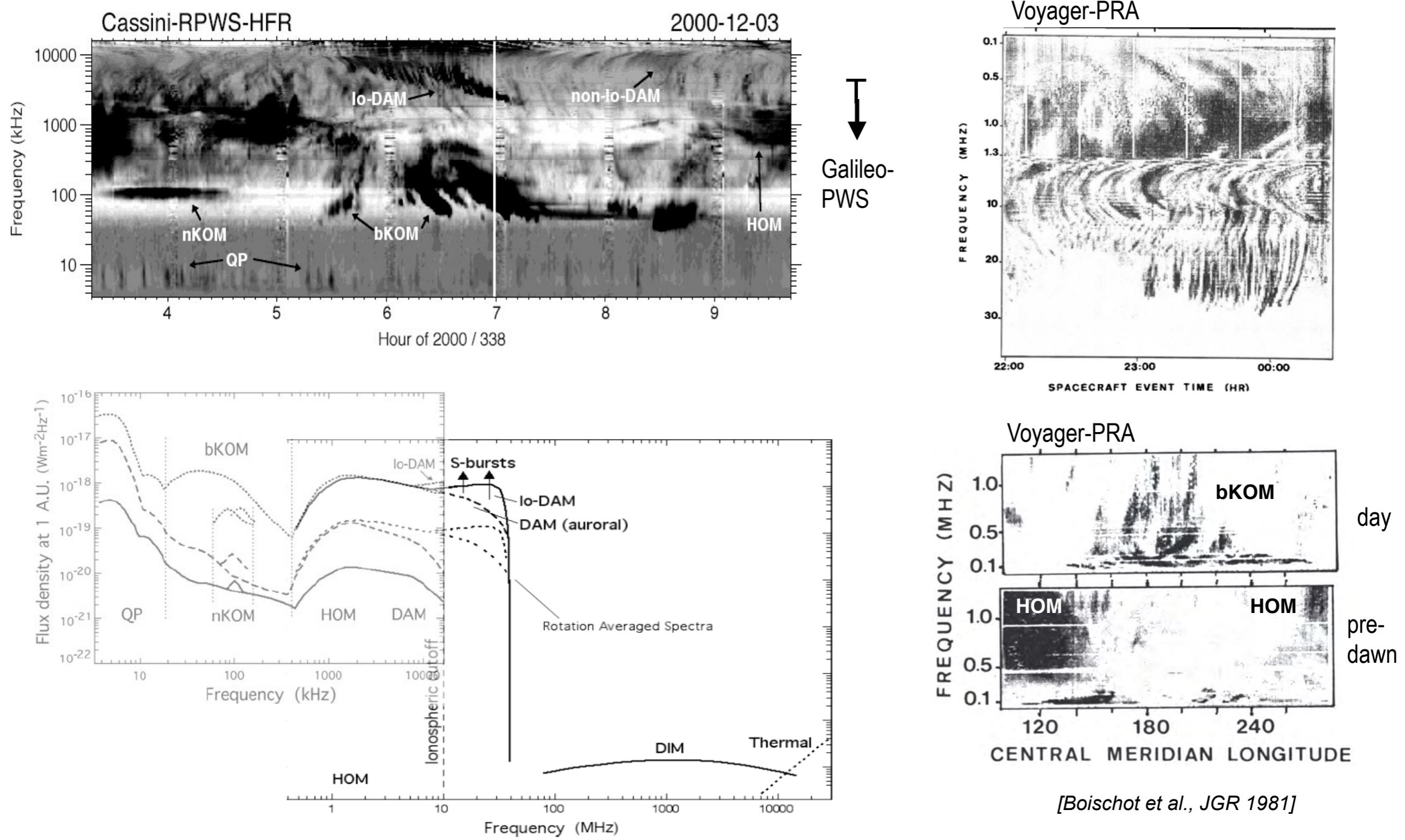


Radio emission mechanisms

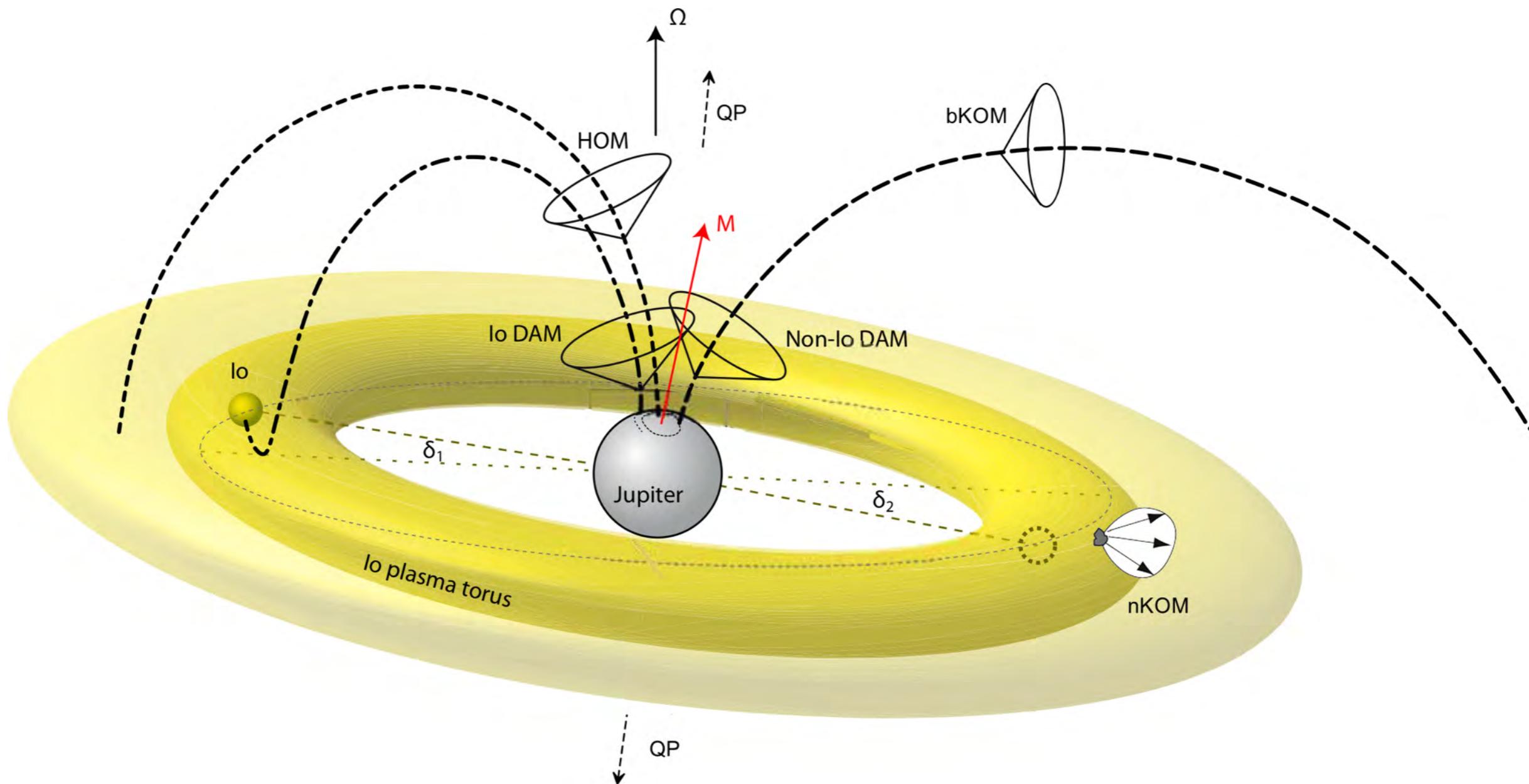
Philippe Zarka

LESIA & USN, Obs. Paris, CNRS, PSL/SU/UPMC/UPD/SPC/UO/OSUC, France

Jupiter radio "zoo"



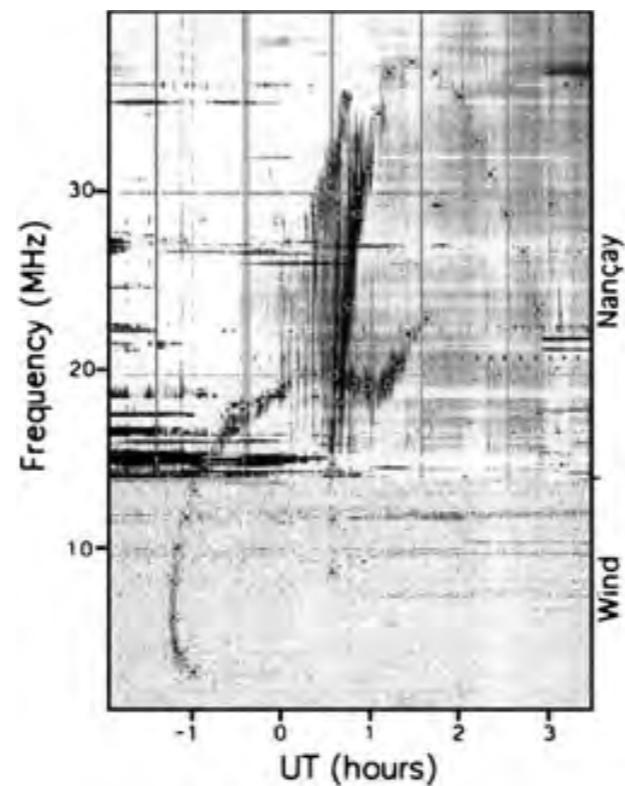
Source locations



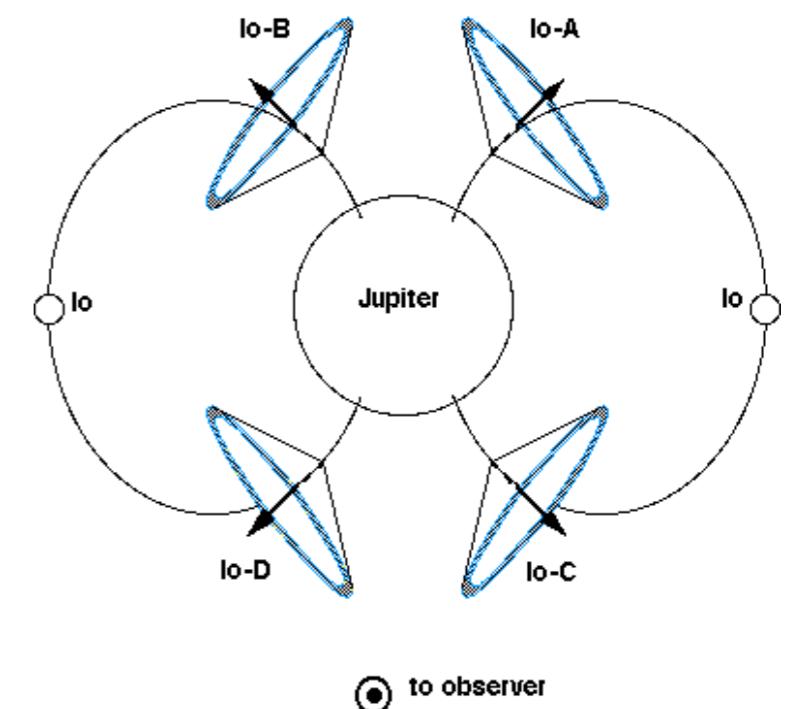
[Zarka, JGR 1998, Geophys. Mon. 2000]

Decameter arcs

- Io-Jupiter,
satellite-Jupiter ?

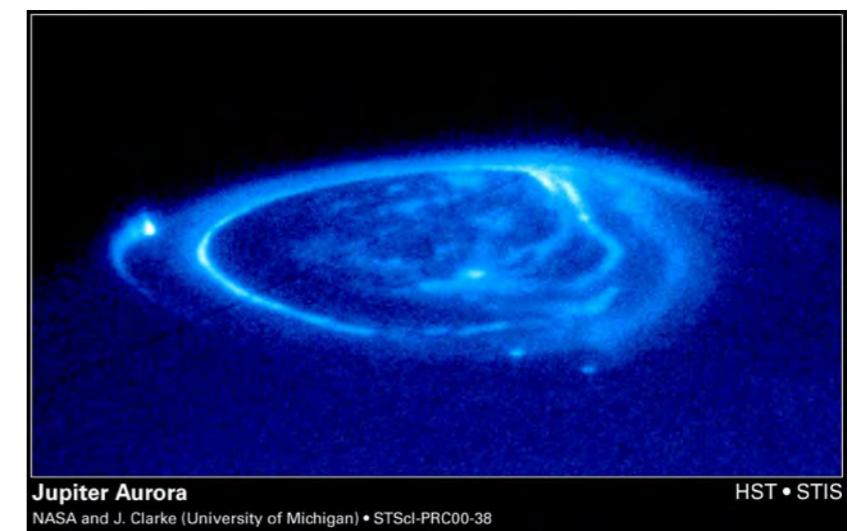
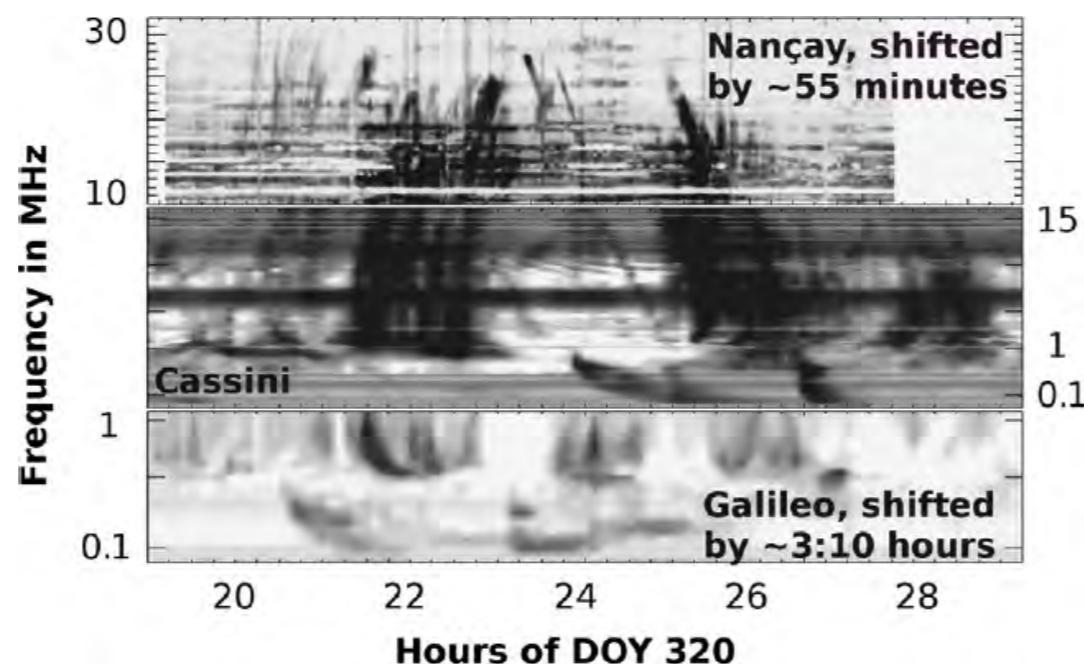


Io-controlled radio "sources"



[Queinnec & Zarka, JGR 1998 ; ...]

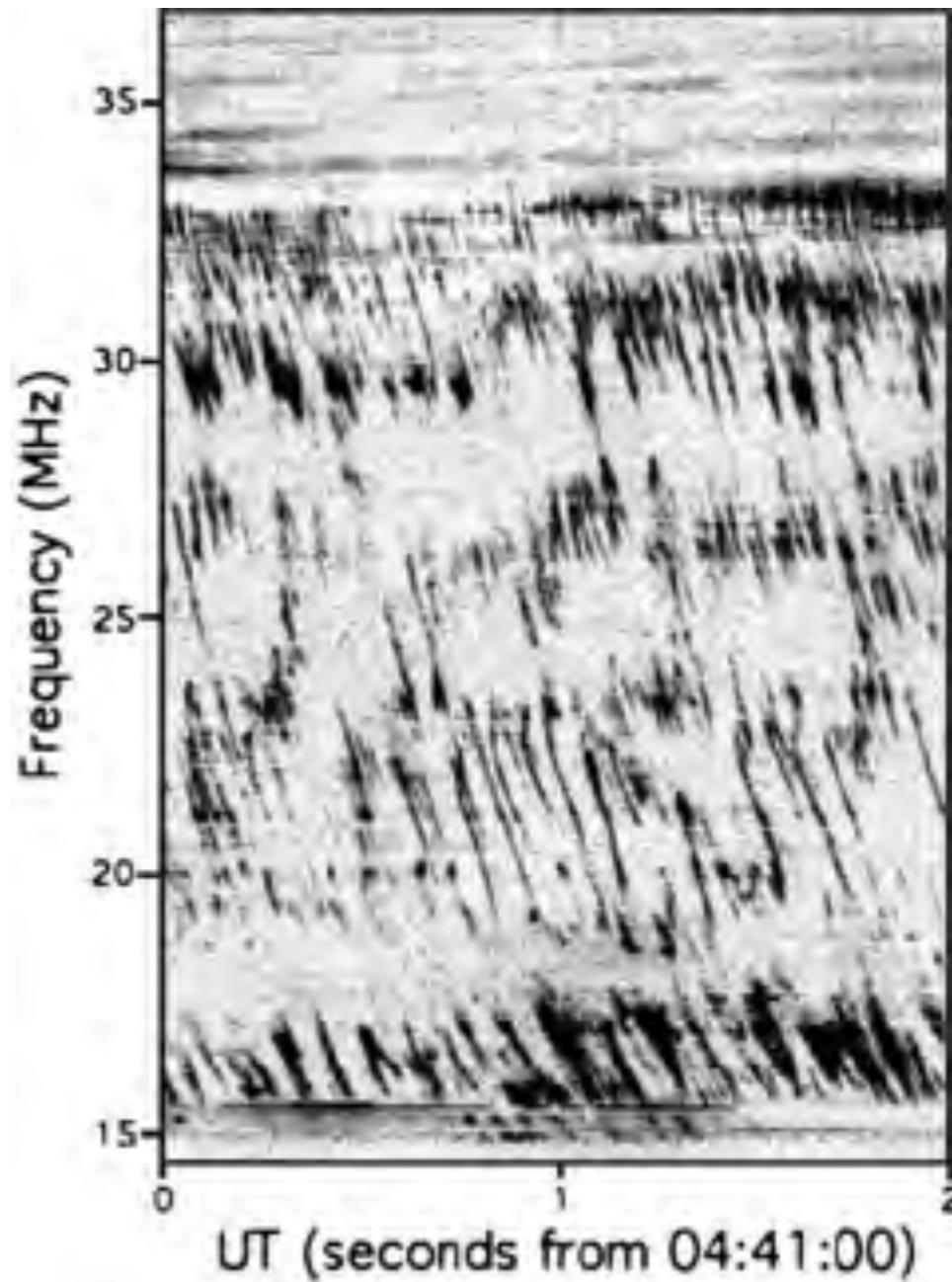
- Auroral



[Hess et al., PSS 2014]

Decameter (S-)bursts

- discrete
- fast drifting with $df/dt < 0$
- quasi-periodic
- complex envelope



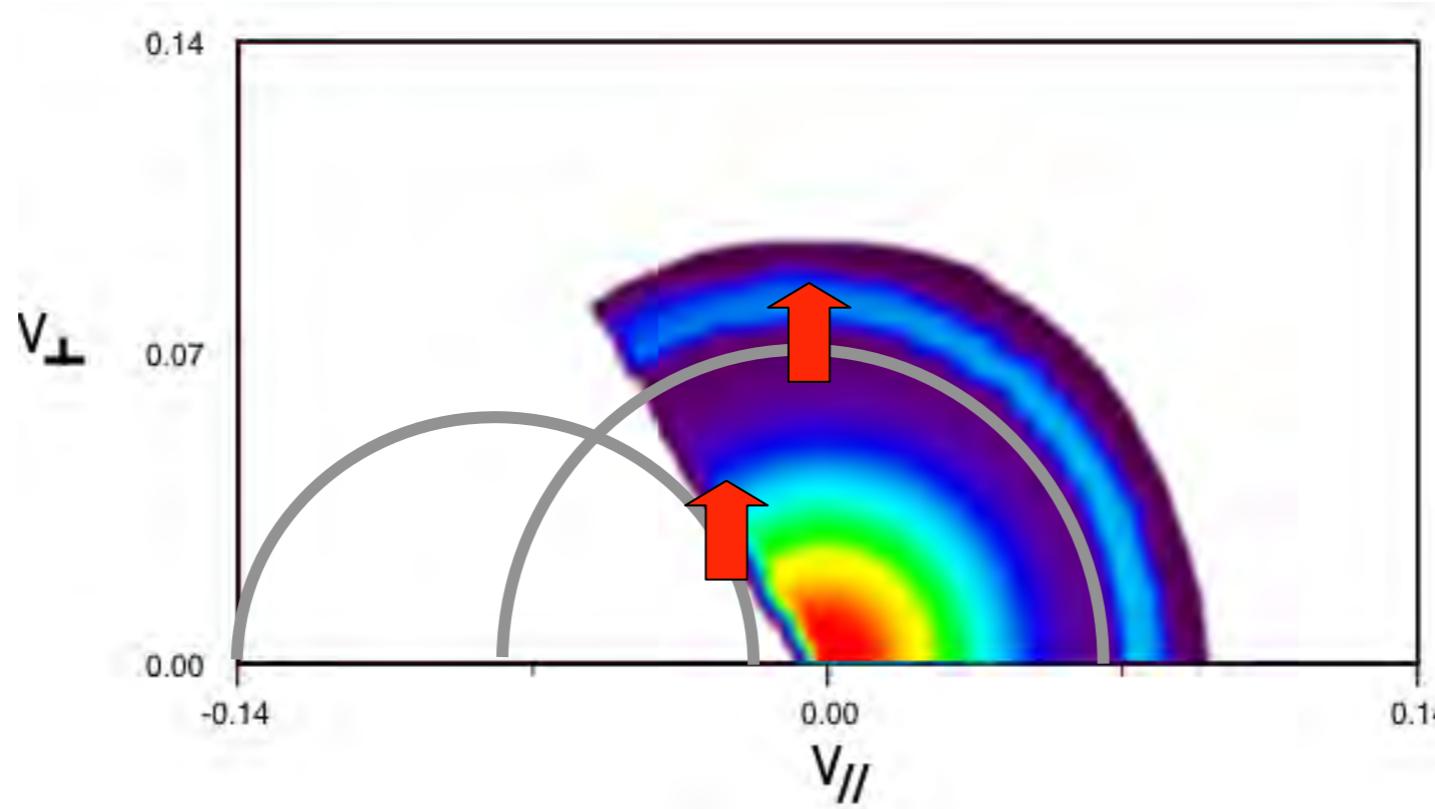
[Ryabov et al., A&A 2014 ; ...]

Radiation mechanism

- DAM / HOM / bKOM ? : Cyclotron Maser Instability

Resonance condition : $\omega = \omega_c/\Gamma - k_{\parallel}v_{\parallel}$

Growth rate : $\gamma = \frac{\omega_p^2 c^2}{8\omega_c} \int_0^{2\pi} v_{\perp}^2(\theta) \nabla_{v_{\perp}} f(\mathbf{v}_0, \mathbf{R}(\theta)) d\theta$

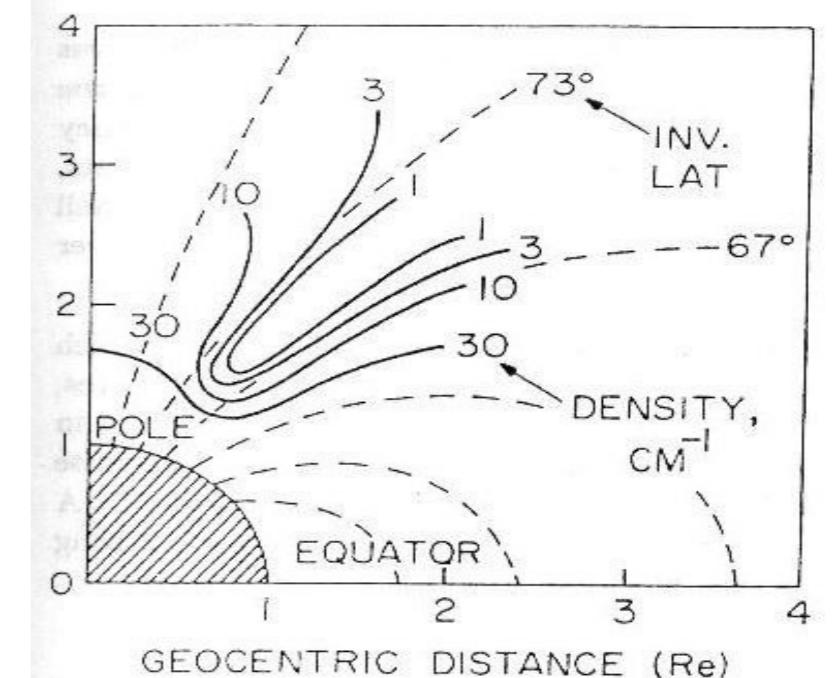
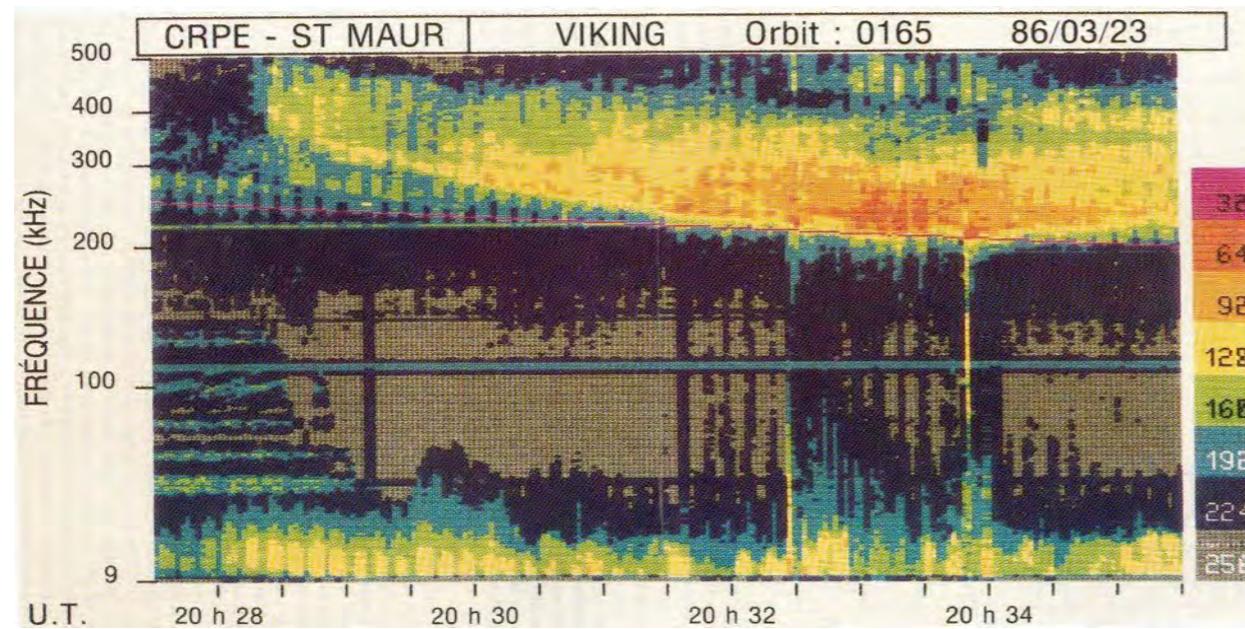


[Wu, SSR 1985 ; Treumann, AAR 2006]

- Regime of operation : Oblique/Loss-cone-driven or Perpendicular/Shell-driven ?

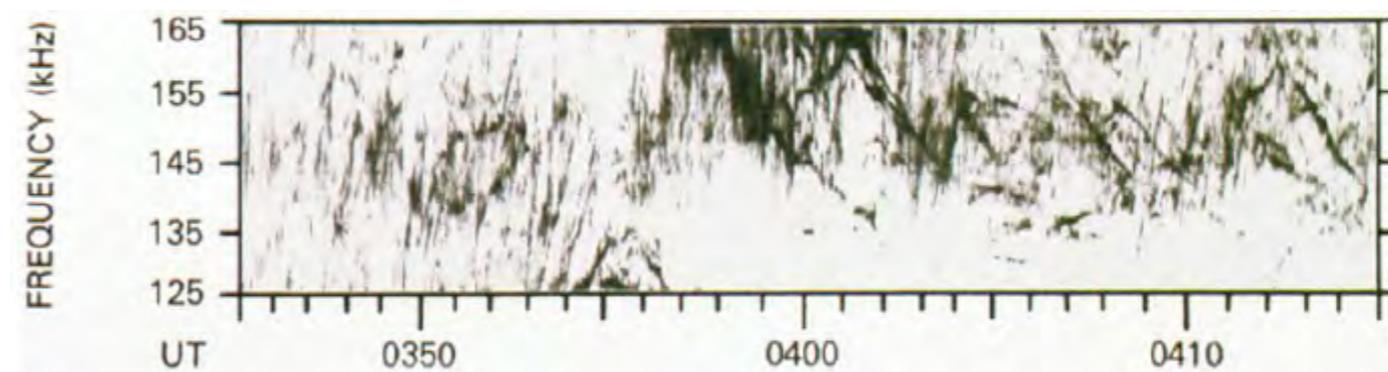
Earth's AKR

- AKR only in hot plasma cavities



[Roux et al., JGR 1993]

- $df/dt > 0$ and < 0

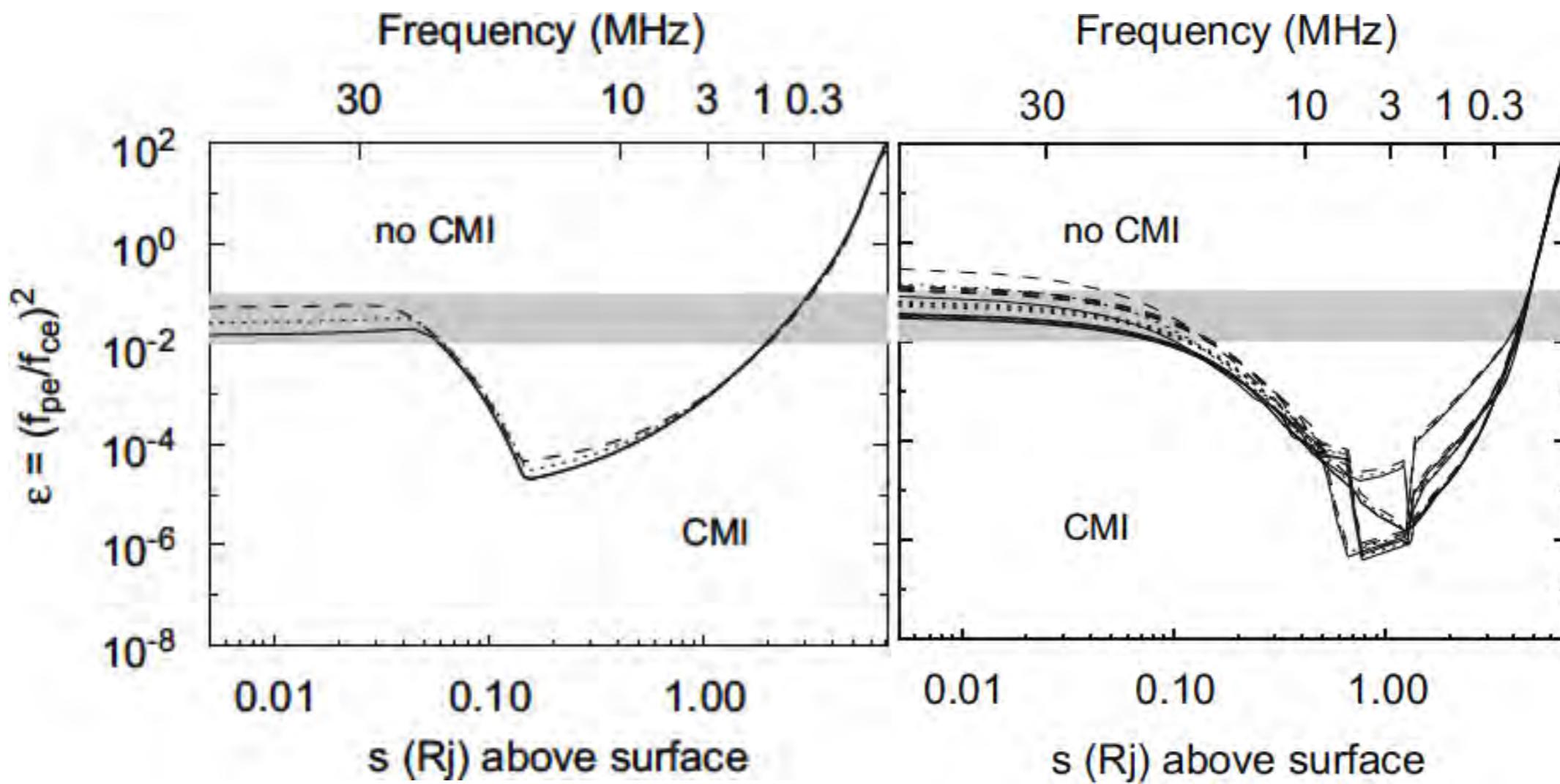


[Baumback & Calvert, 1987]

- Perpendicular/Shell-driven CMI → associated to acceleration structures

Jovian DAM arcs

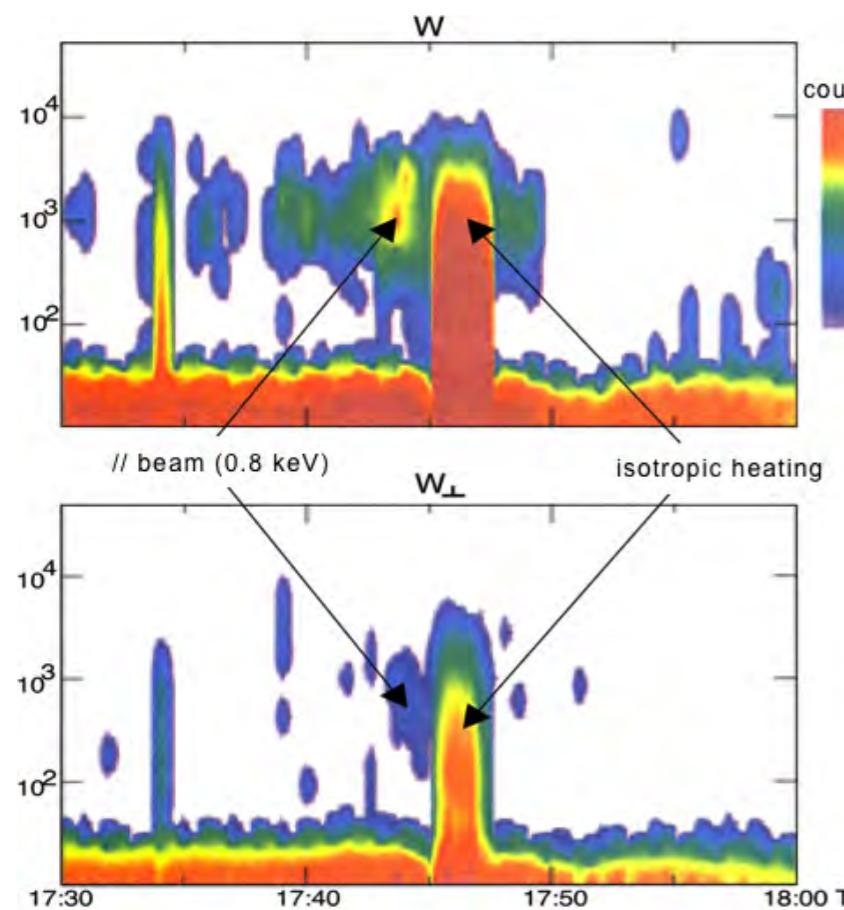
- Cold plasma dominates (no plasma cavities ?)



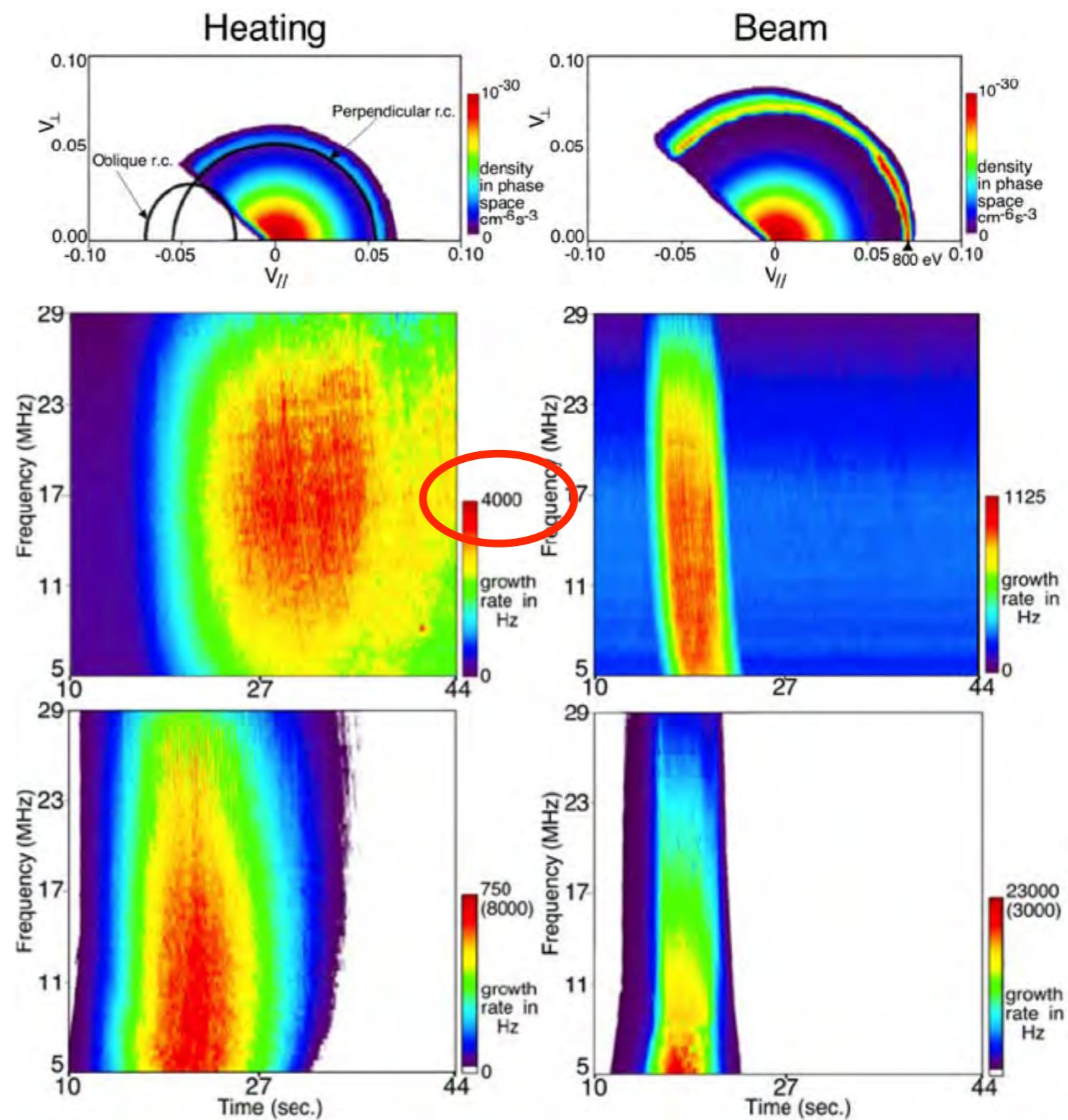
[Zarka et al., PSS 2001 ; Su et al., JGR 2003 ;]

Jovian DAM arcs

- Oblique/Loss-cone-driven CMI has large growth rates



[Frank & Paterson, 1999]

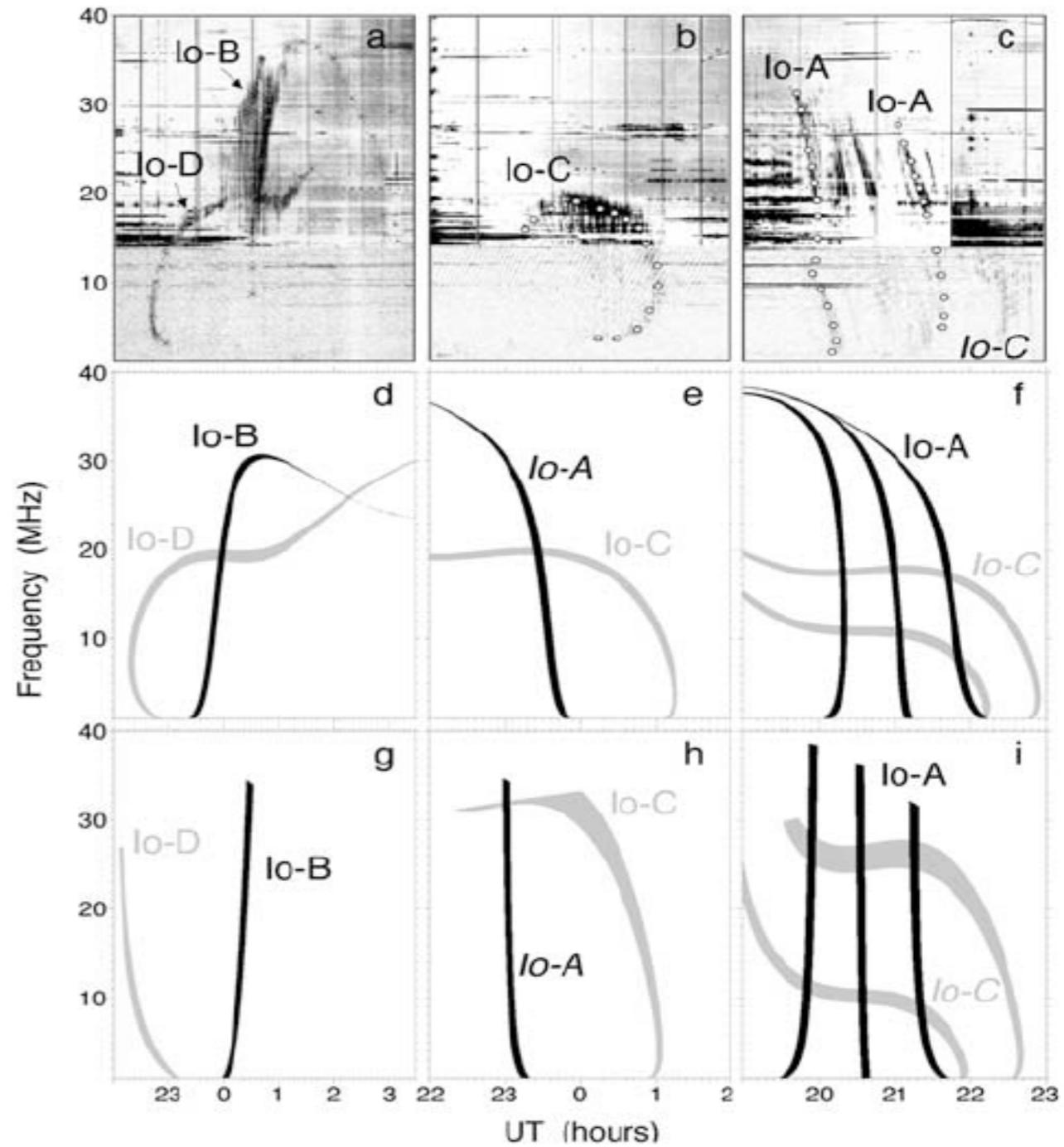
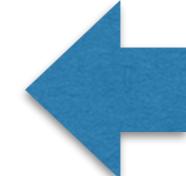
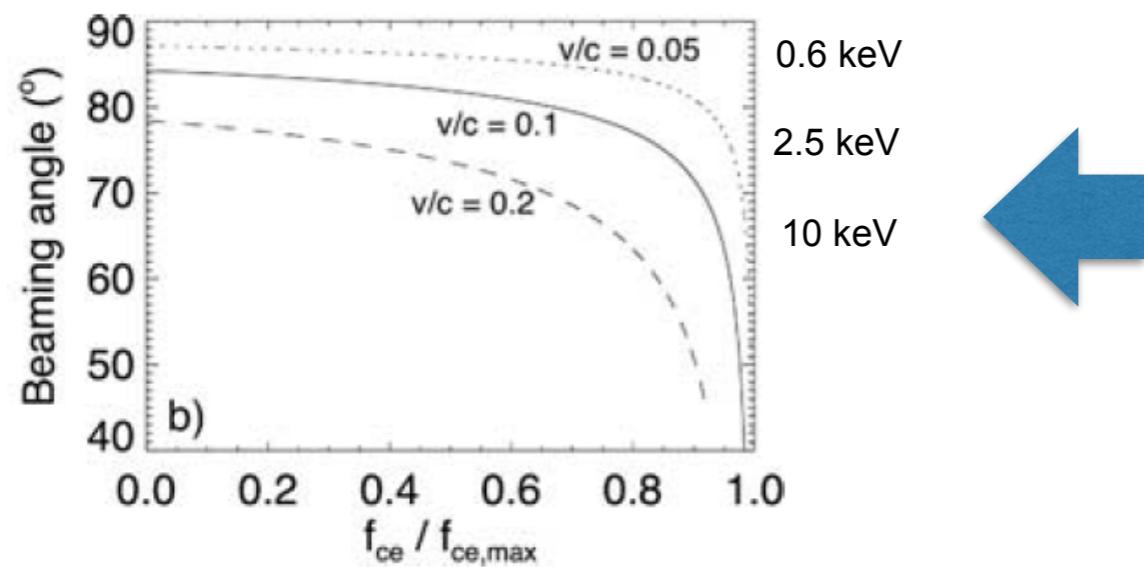


[Hess et al., JGR 2008]

Oblique/Loss-cone Perp./Shell

Jovian DAM arcs

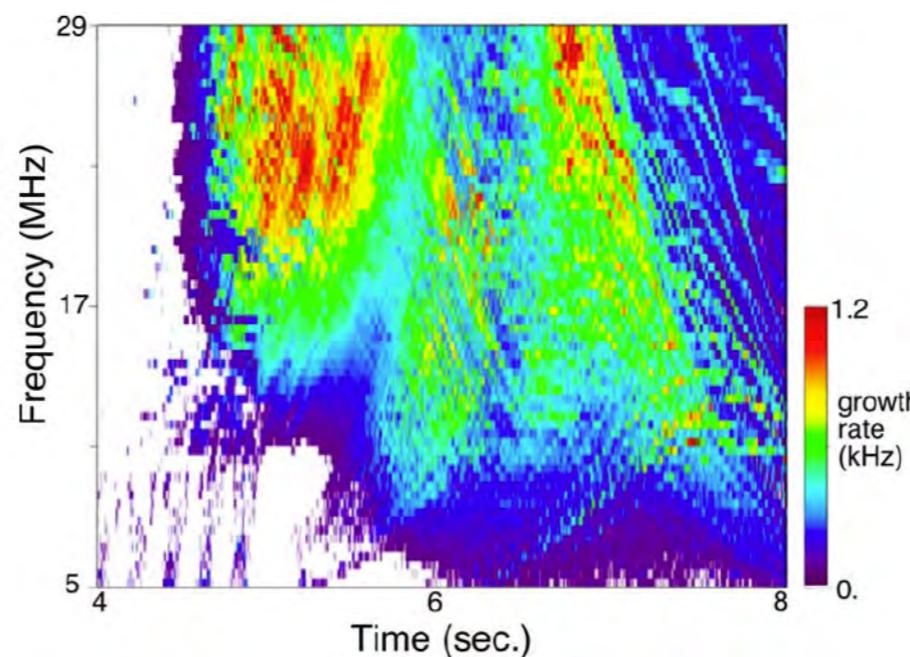
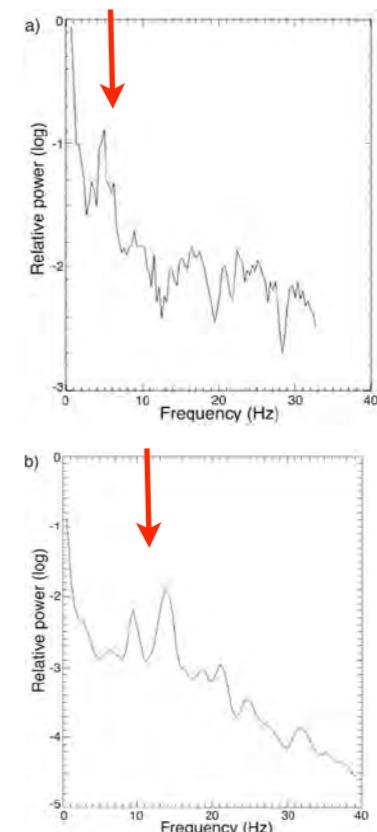
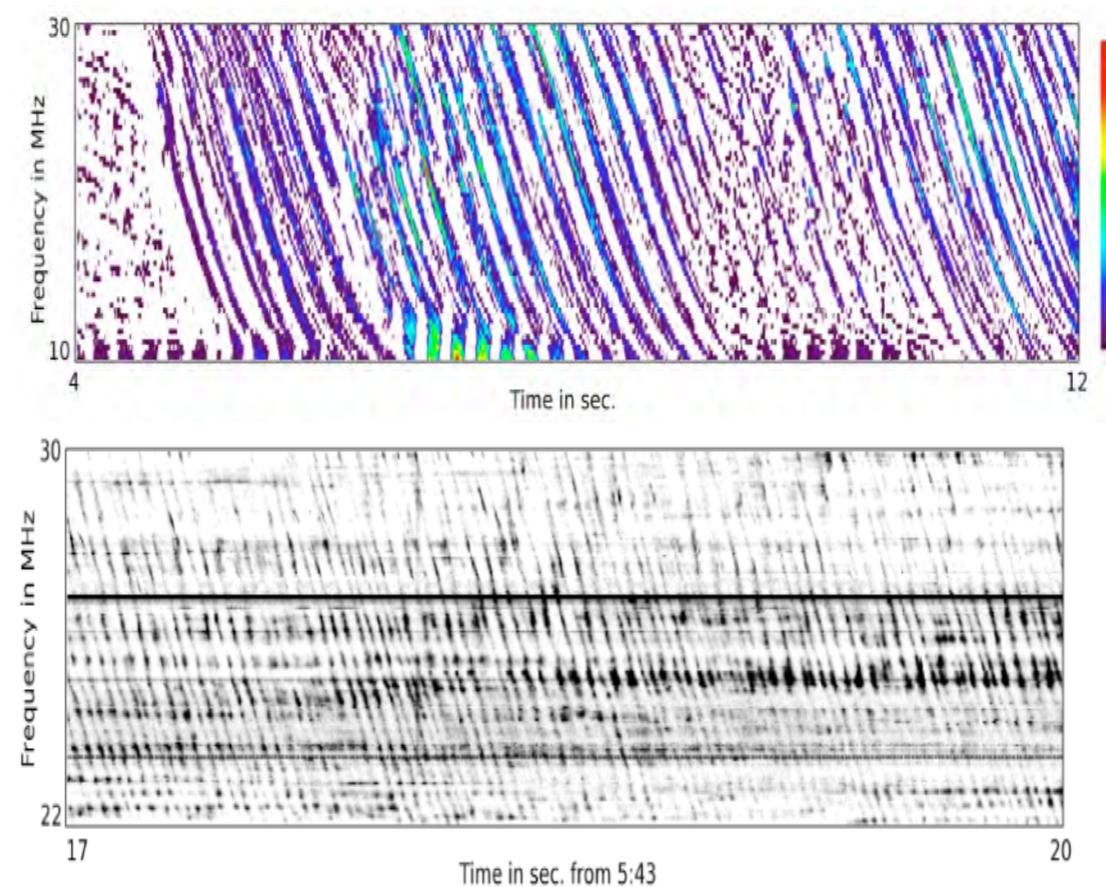
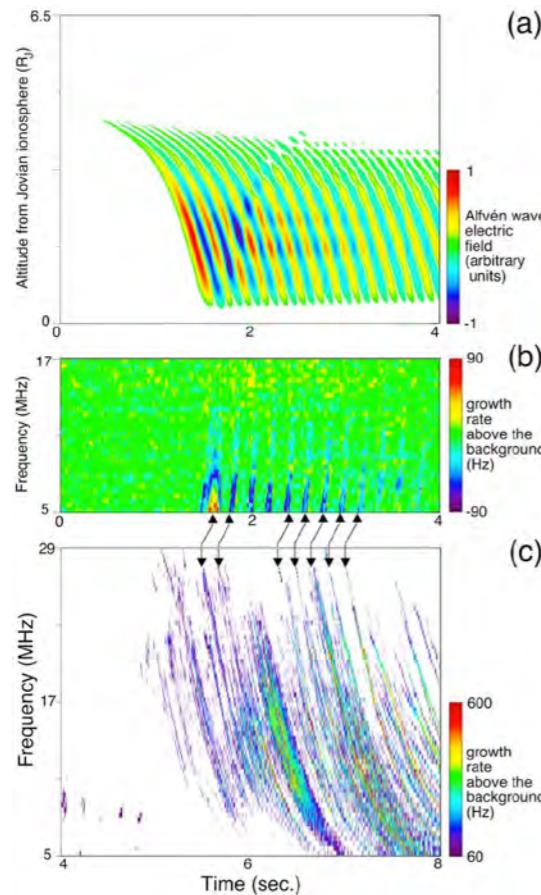
- ExPRES(SERPE) modeling : favours Oblique/Loss-cone-driven CMI



Oblique/Loss-cone
Perp./Shell

Jovian S-bursts

- Oblique/Loss-cone-driven emission from Alfvén waves acceleration of electrons



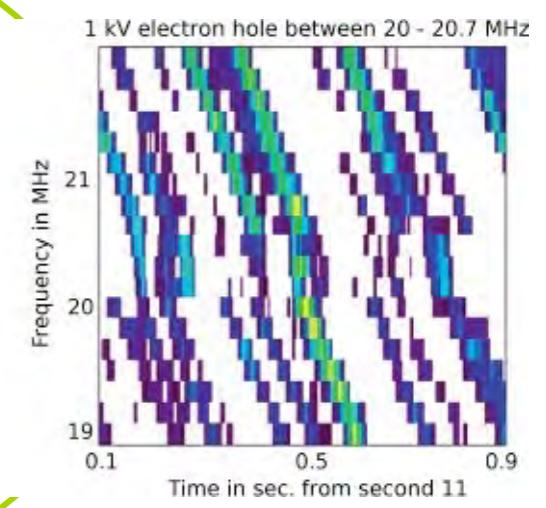
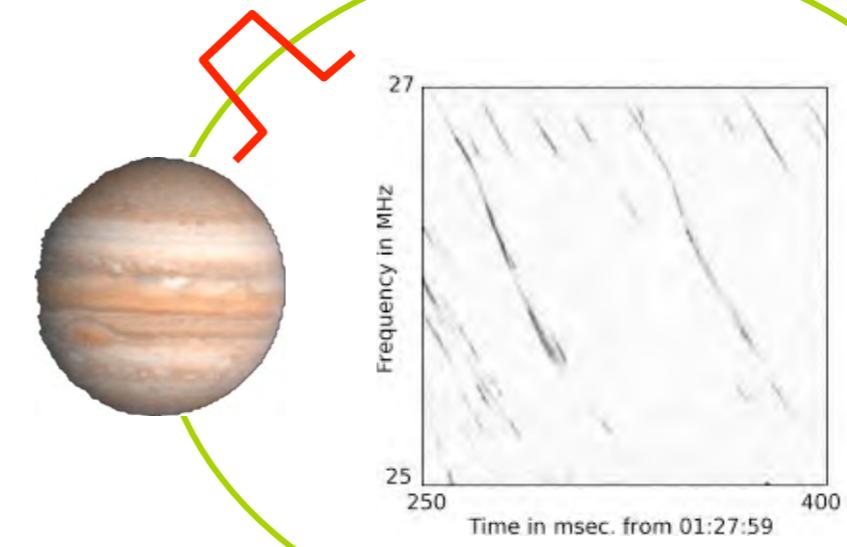
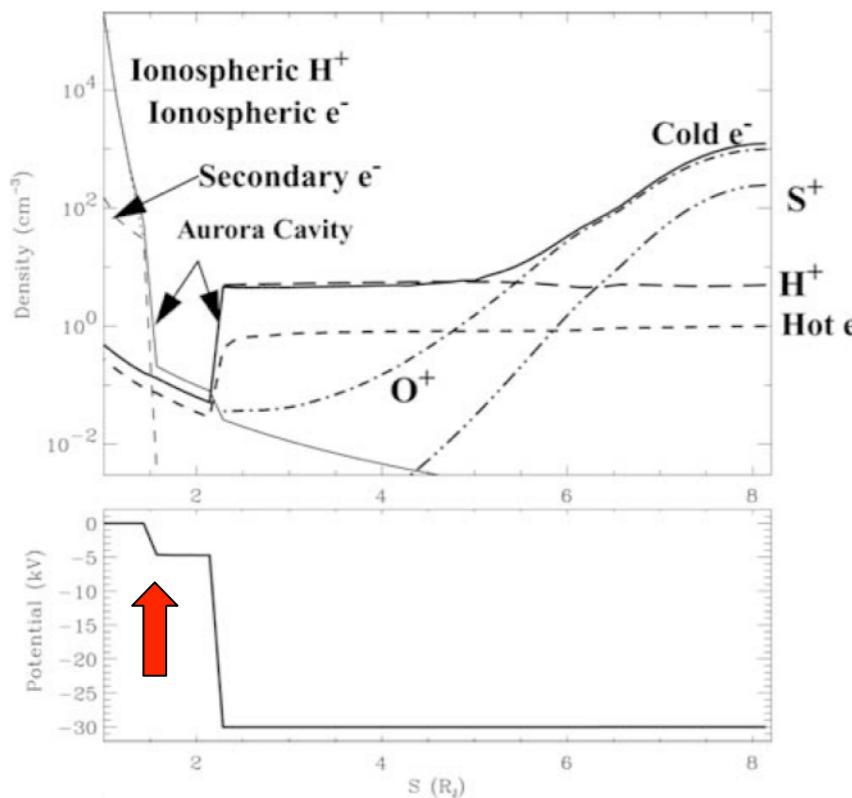
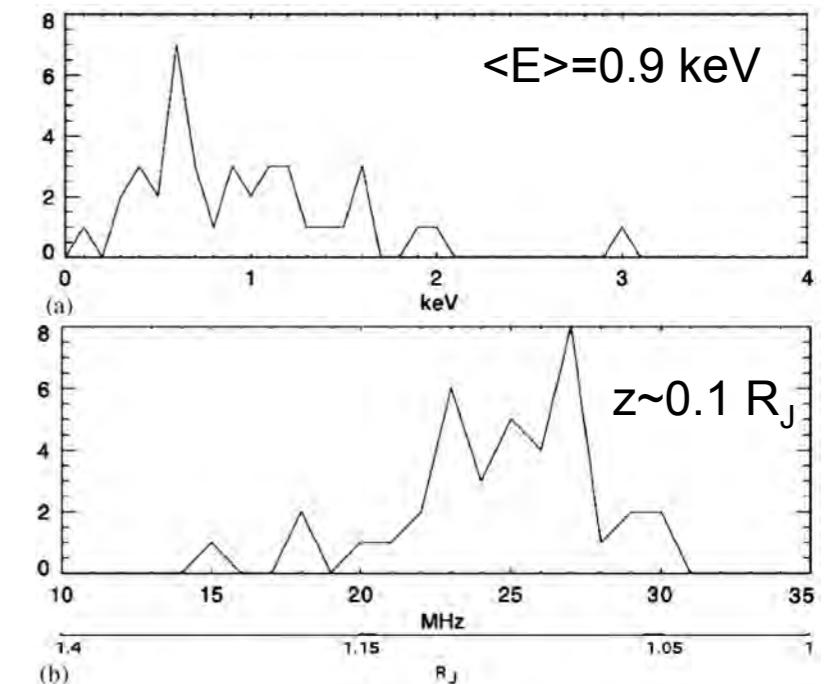
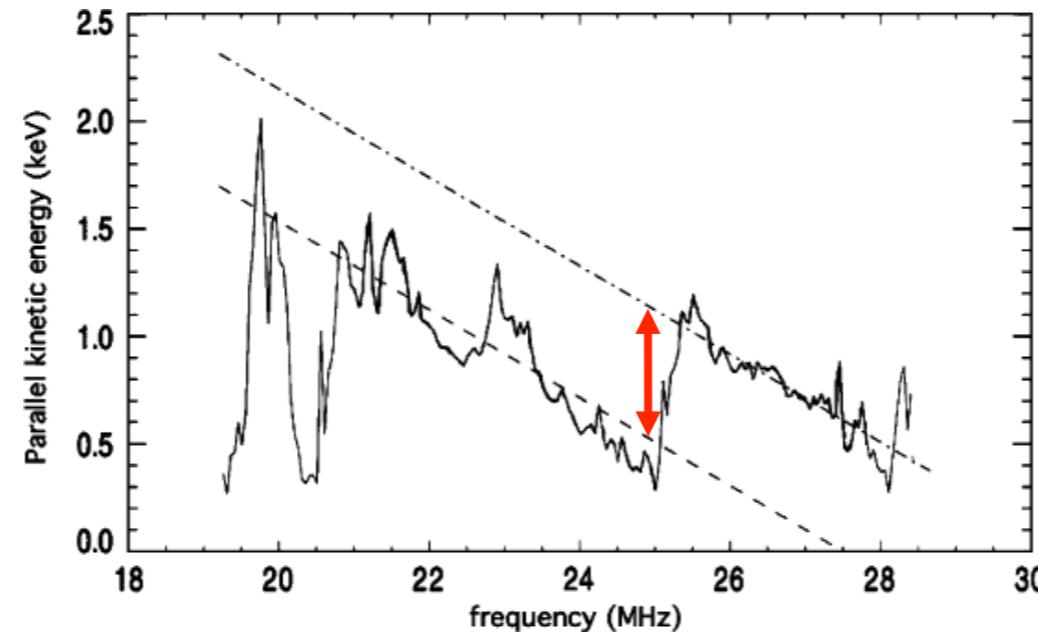
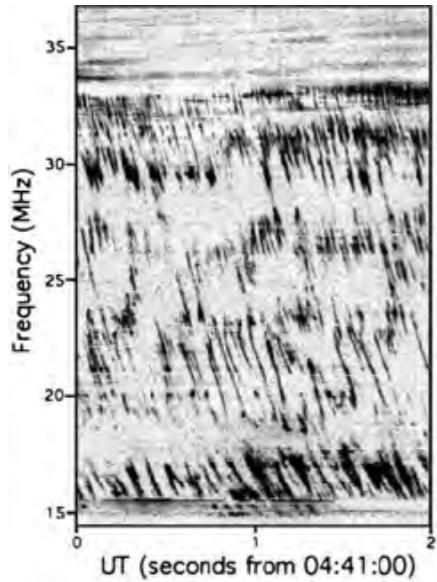
Perp./Shell

[Hess et al., JGR 2007, GRL 2009]

Oblique/Loss-cone

Jovian S-bursts

- Double-layers / electron & ion holes along IFT ...



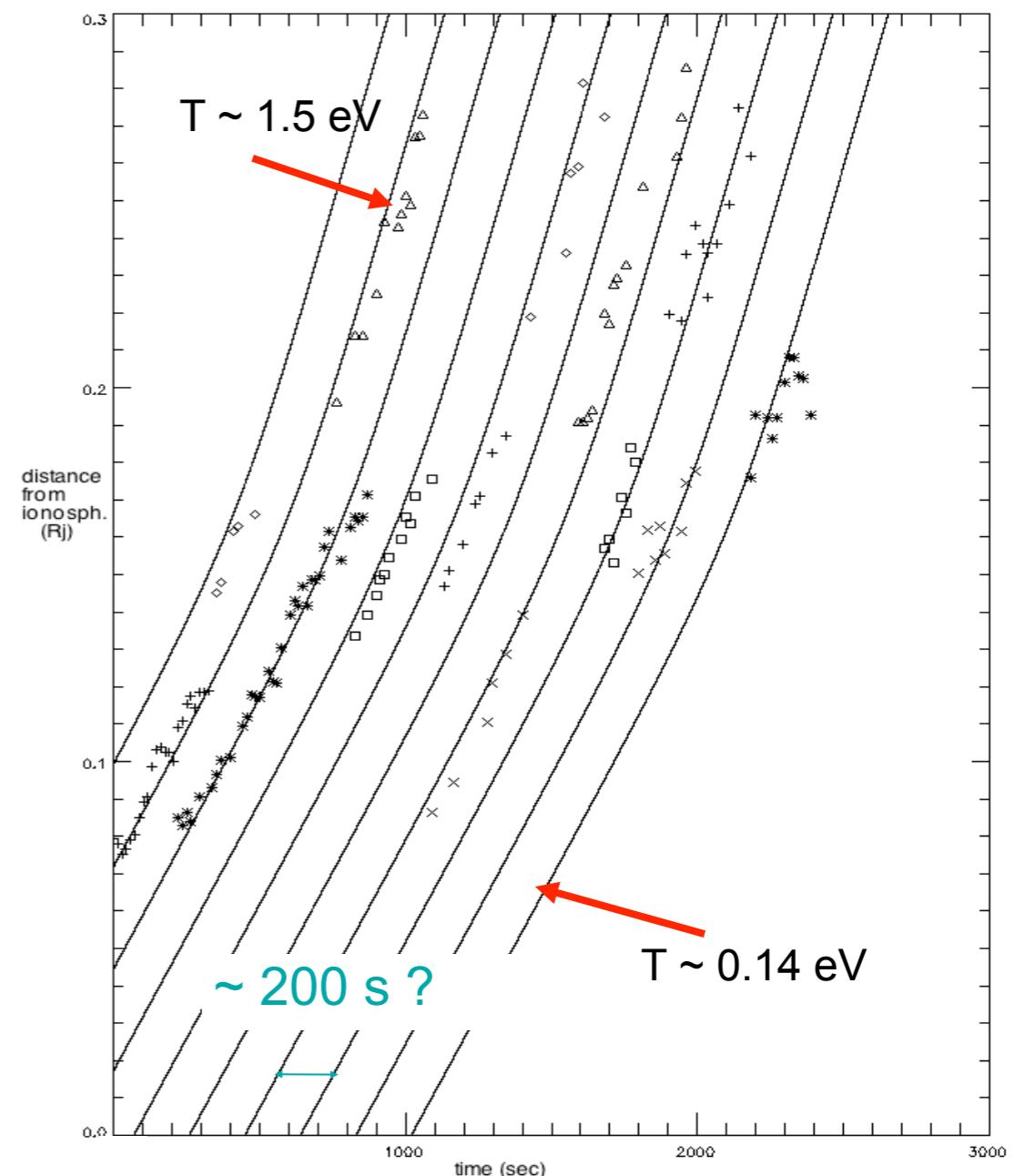
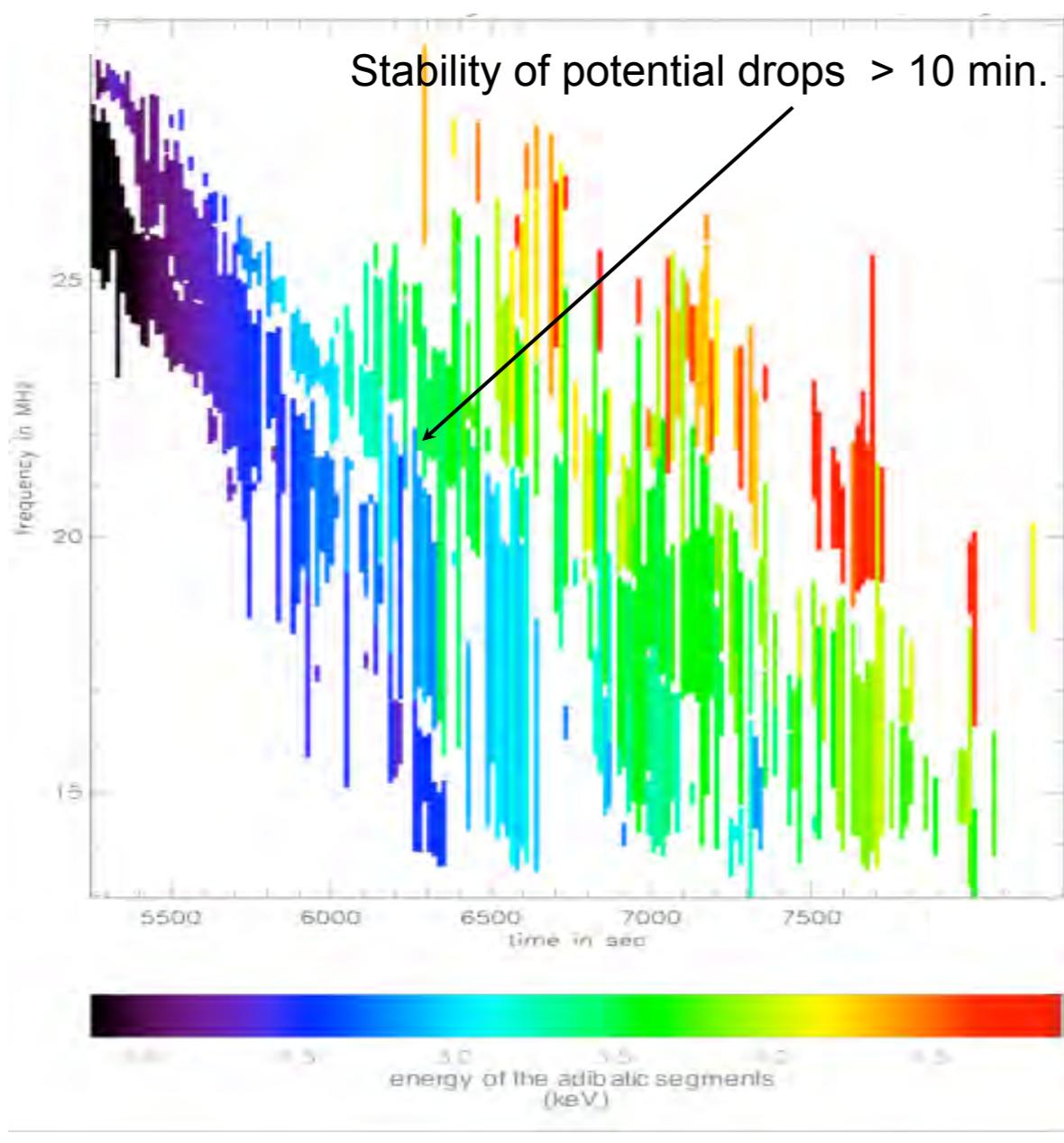
[Su et al., JGR 2003]

[Hess et al., GRL 2009]

[Hess et al., PSS 2007]

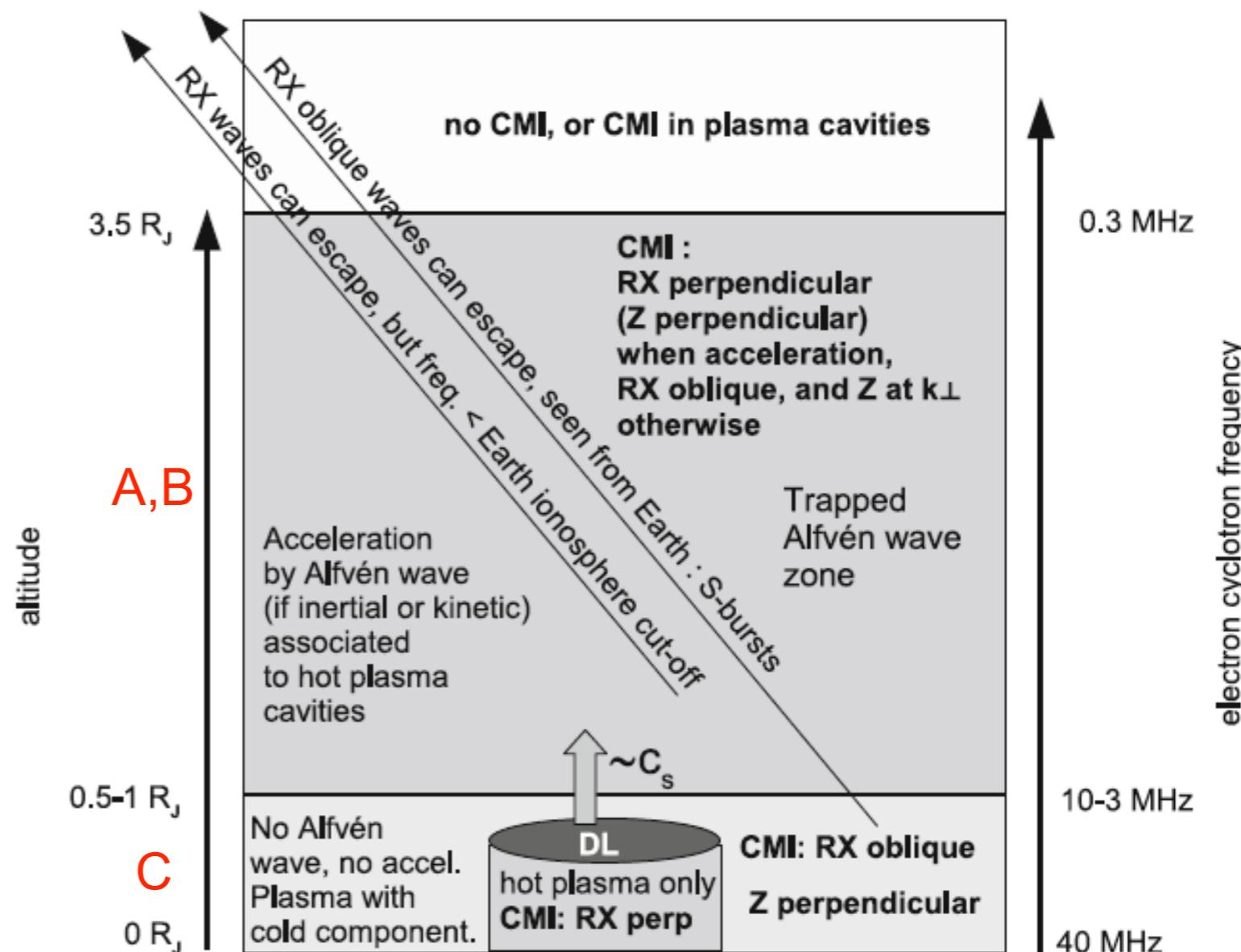
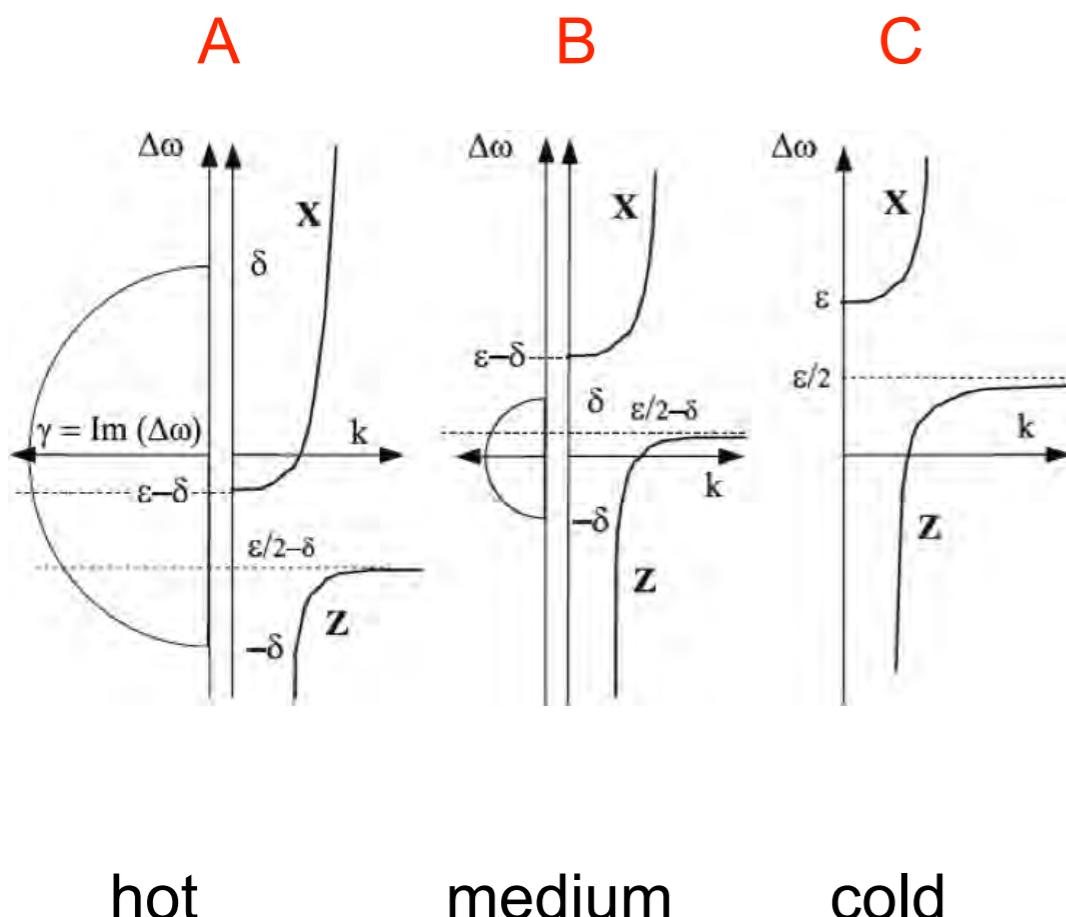
Jovian S-bursts

- ... in motion along the IFT at the local plasma sound velocity

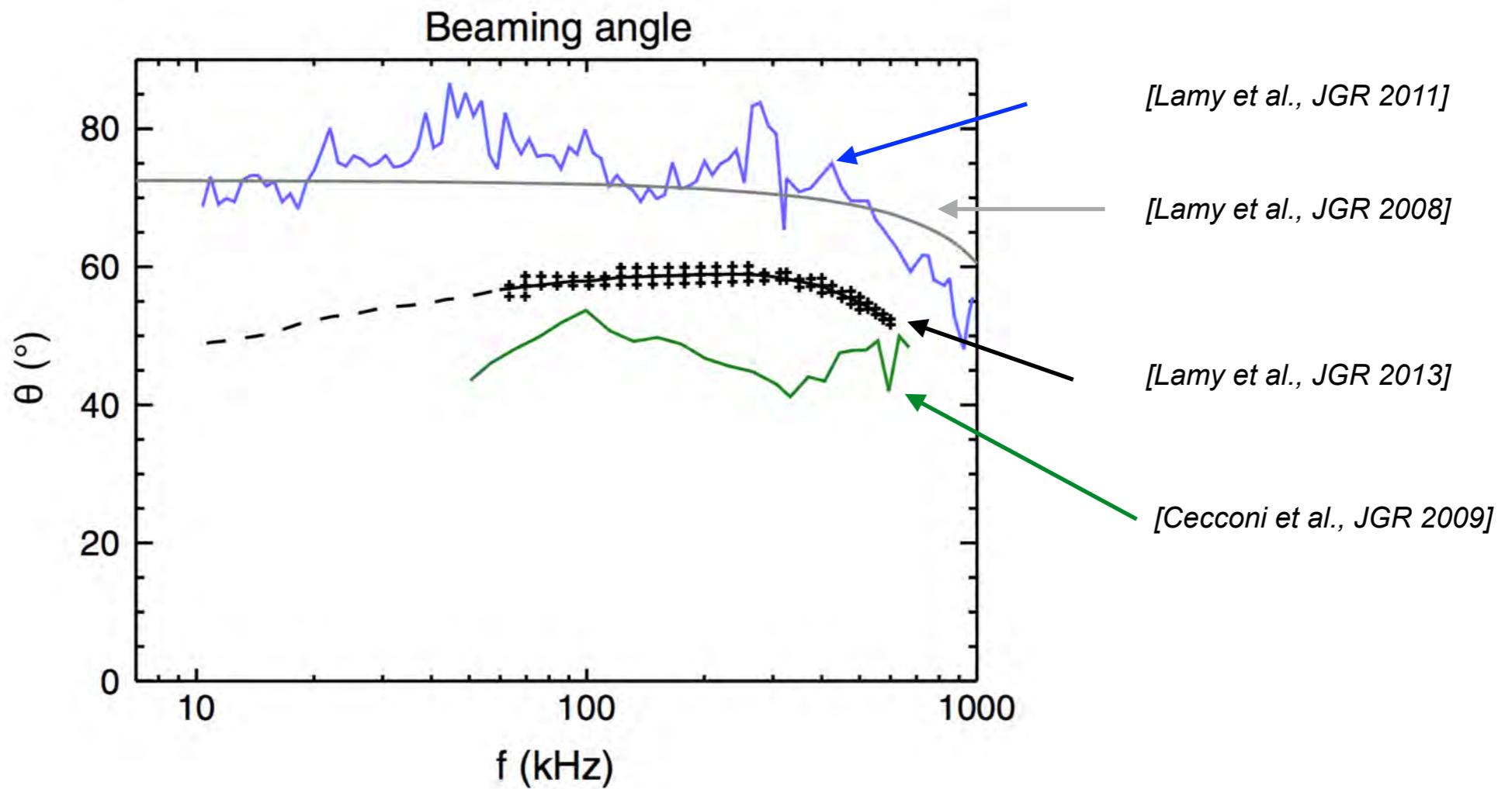


Why oblique mode dominant for Jovian DAM ?

perpendicular propagation



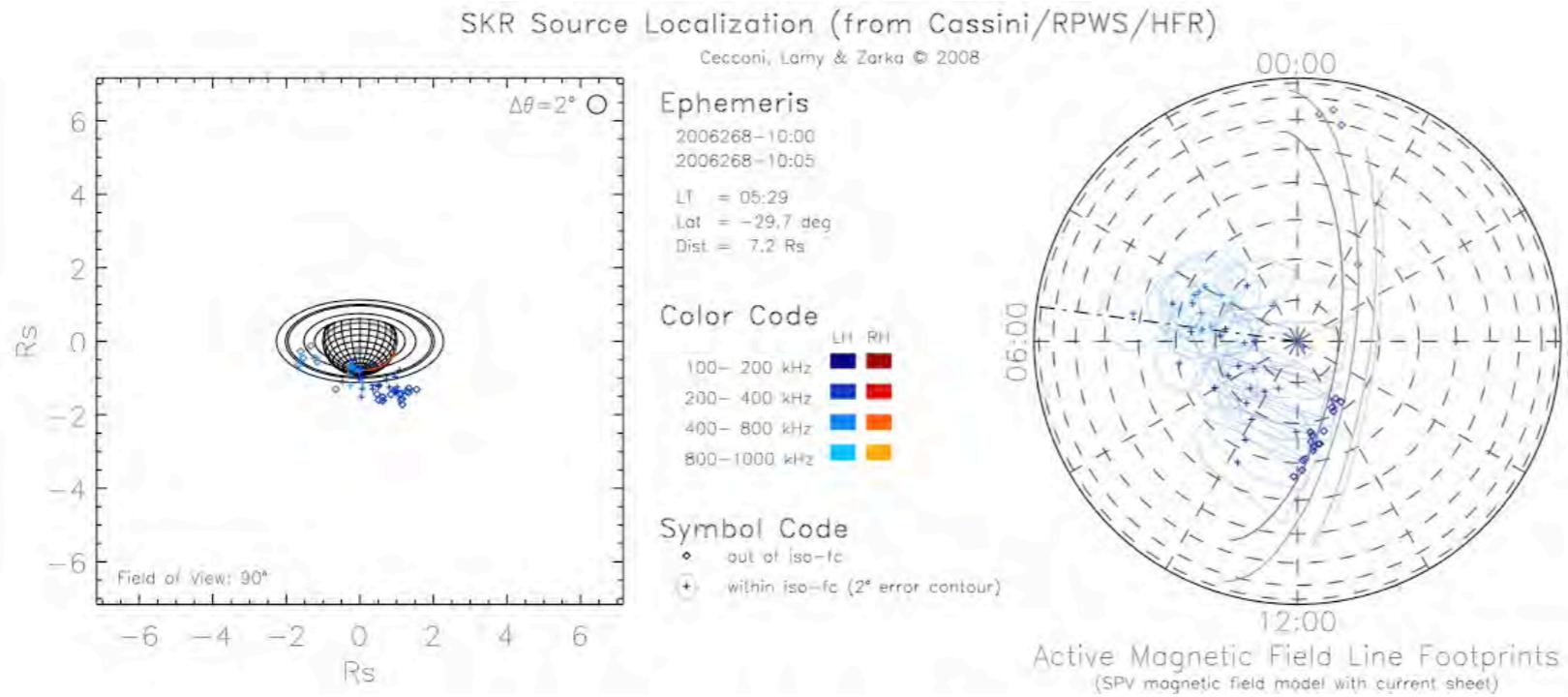
SKR beaming



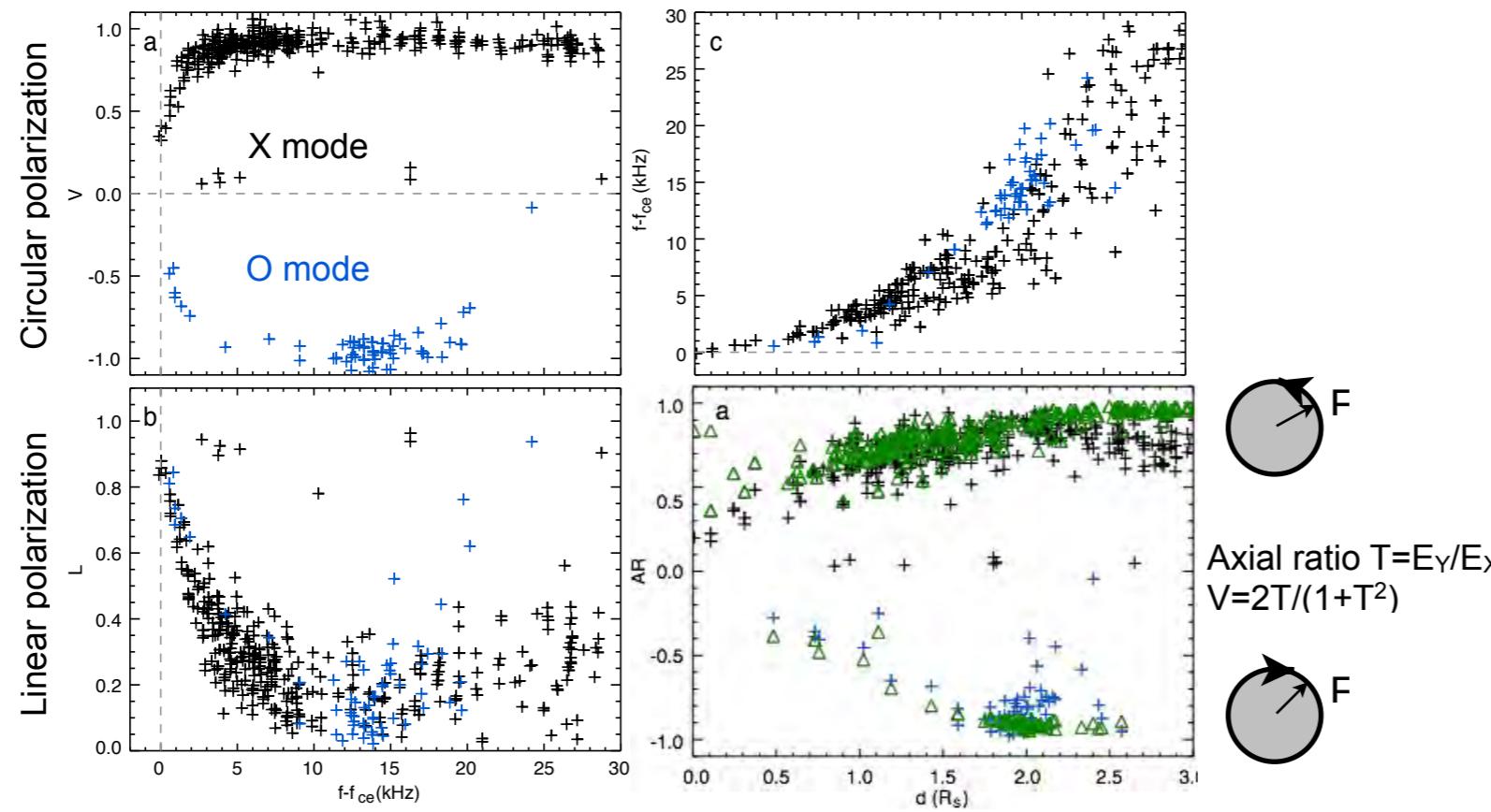
- Remote observations : oblique beaming
- In situ observations : quasi-perpendicular emission

→ role of refraction ?

What JUNO will not do



[Cecconi et al., JGR 2009]



[Lamy et al., JGR 2011]

→ no direct source location, no strong constraint on emission mode, except with S/C spin ?

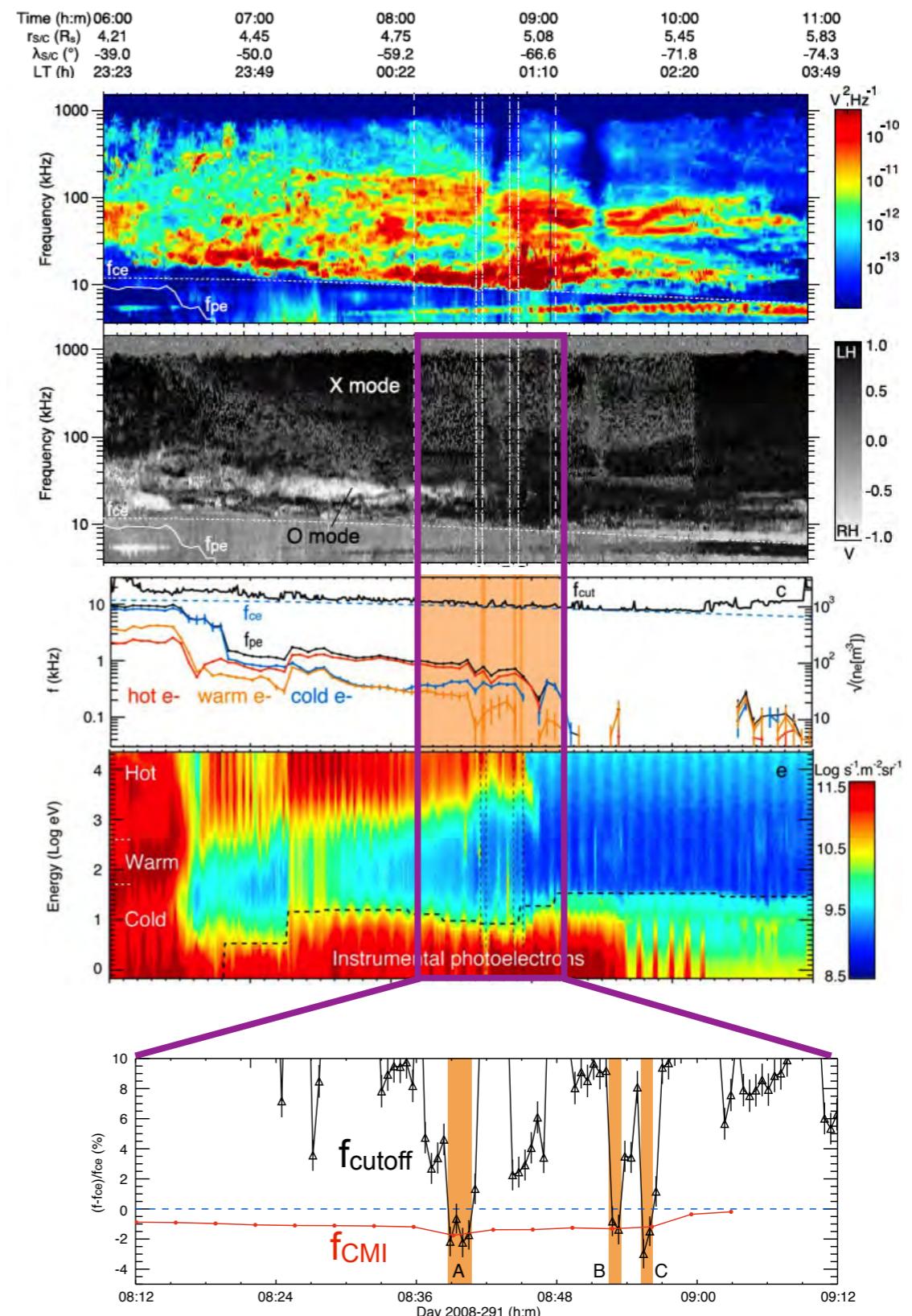
What JUNO will do

- Wave+particle measurements during high latitude sources traversals

→ comparisons with SKR & AKR

[Lamy et al., 2010, 2011,
 Mutel et al., 2010,
 Bunce et al., 2010,
 Schippers et al., 2011,
 Kurth et al., 2011,
 Menietti et al., 2011]

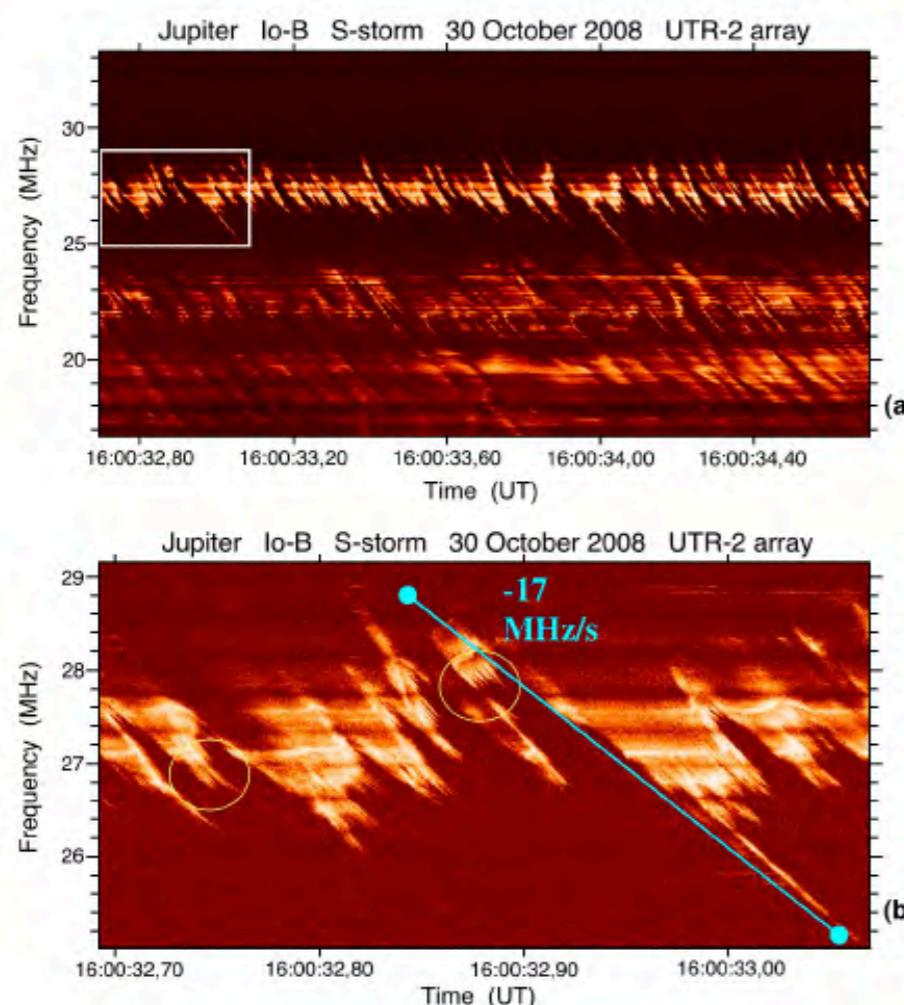
→ f_{CMI} down to several % below f_{ce}
 above aurora at Jupiter ?



What JUNO will do

- Wave+particle measurements during high latitude sources traversals

→ S-bursts envelope ?



[Ryabov et al., A&A 2014]

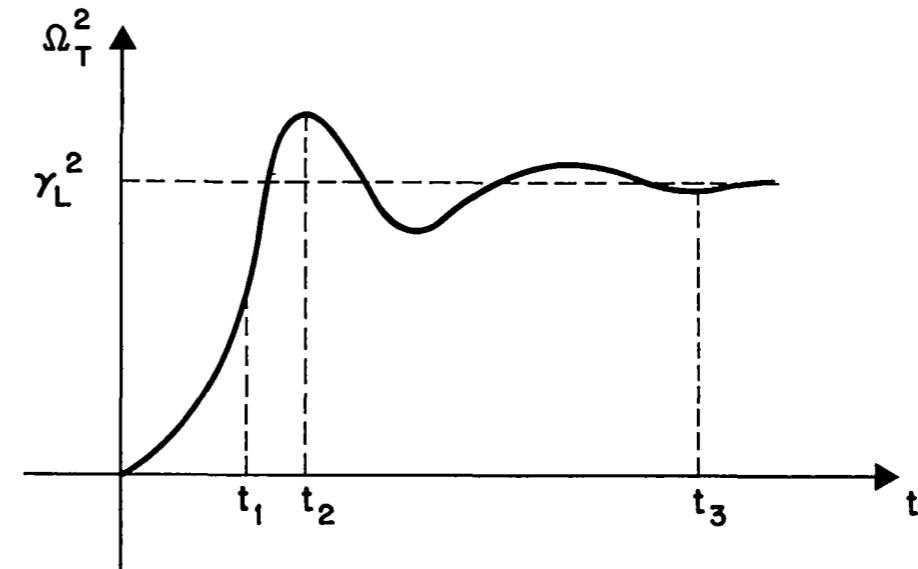
→ Max. E field in sources ?

(predicted 1-10 V/m)

[Zarka, Juno memo 2006]

→ CMI saturation ?

[Zarka, MOP 2009]



- Identification of saturation mechanism
- Feedback on source plasma content
- Implications on exoplanets

What we will do with JUNO

- ExPRES modeling (CMI + geometry + near source refraction) at all latitudes

Astronomy & Astrophysics manuscript no. article' serpe
November 15, 2014

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ExPRES: a tool to simulate planetary and exoplanetary radio emissions

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² Department of Space Environment, ONERA - The French Aerospace Lab, France

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Intranet

Mesures, Analyses et Simulations d'Emissions Radio

vendredi 17 juillet 2015, par Baptiste Cecconi

Le portail Maser (Mesures, Analyses et Simulations d'Emissions Radio) donne accès à une série d'outils et à des données liées à la radio astronomie basse fréquence (depuis quelques kilohertz jusqu'à quelques dizaines de MHz). Les mesures radio dans cette gamme spectrale sont effectuées à l'aide d'observatoire sol (pour les fréquences à la coupure ionosphérique de la Terre à 10 MHz) ou depuis des plateformes spatiales (aux plus basses fréquences).

Dans cette gamme de fréquence, les principales sources radio sont le Soleil et les étoiles magnétisées. La mesure des fluctuations basses fréquences des champs électromagnétiques peut aussi fournir des diagnostics sur le plasma local, et des observations de l'interaction des particules d'ondes plasma dans le Vent Solaire et les environnements planétaires.

Accès direct aux principaux services

SERPE JUPITER Cassini/Kronos HELIO-HFC JUNO-Ground-Radio

Explanetary and Planetary Radio Emission Simulator
Simulateur d'Emissions Radio Planétaires et Exoplanétaires

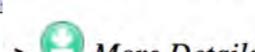
ExPRES requiring each user to have its own workspace, persons willing to use ExPRES must first be registered. If you are not or have difficulties to connect, please contact sebastien.hess -at- latmos.ipsl.fr

Login:

Password:

Submit

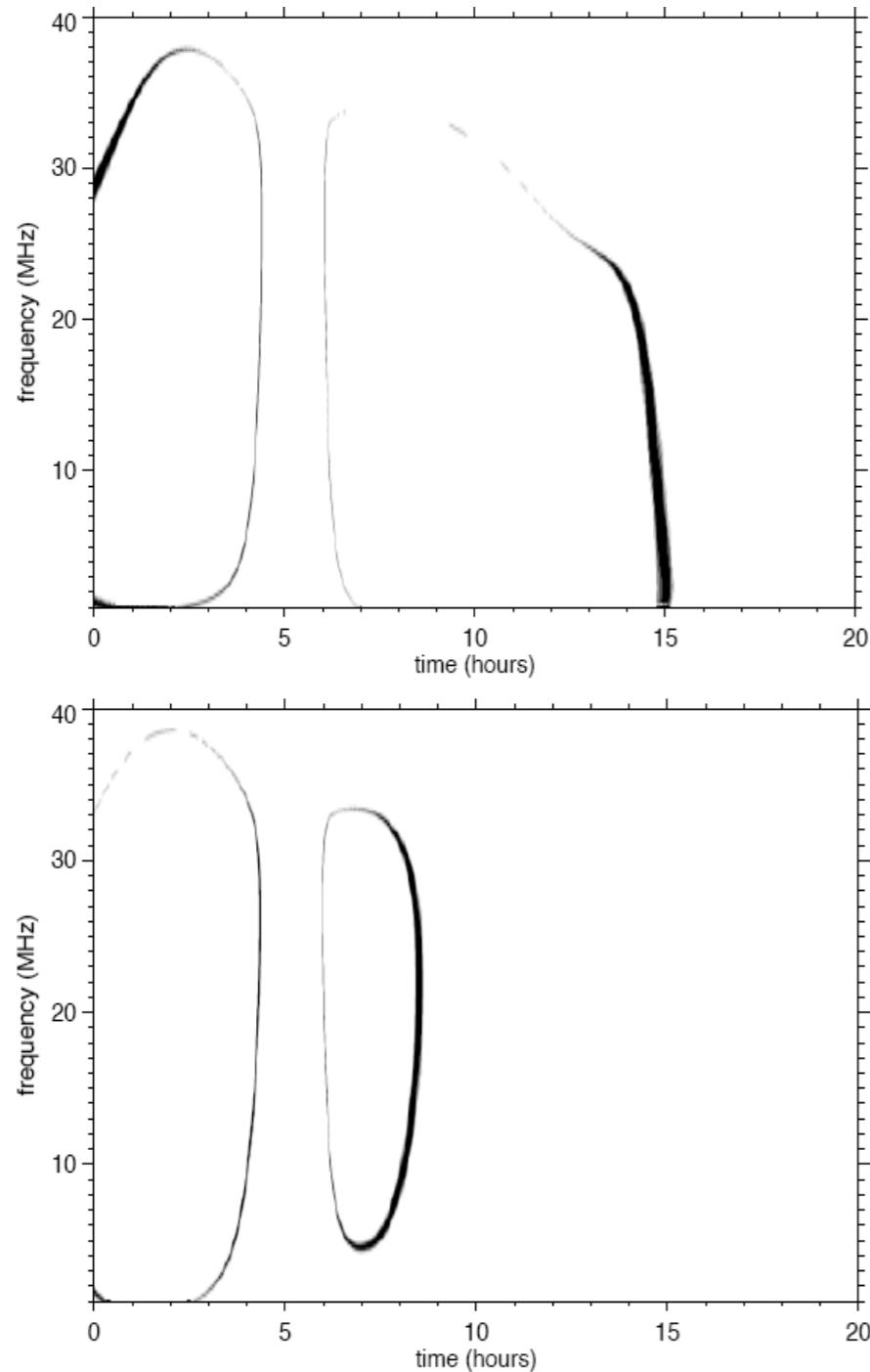
New: The ExPRES User's Guide is now available in PDF version



More Details

What we will do with JUNO

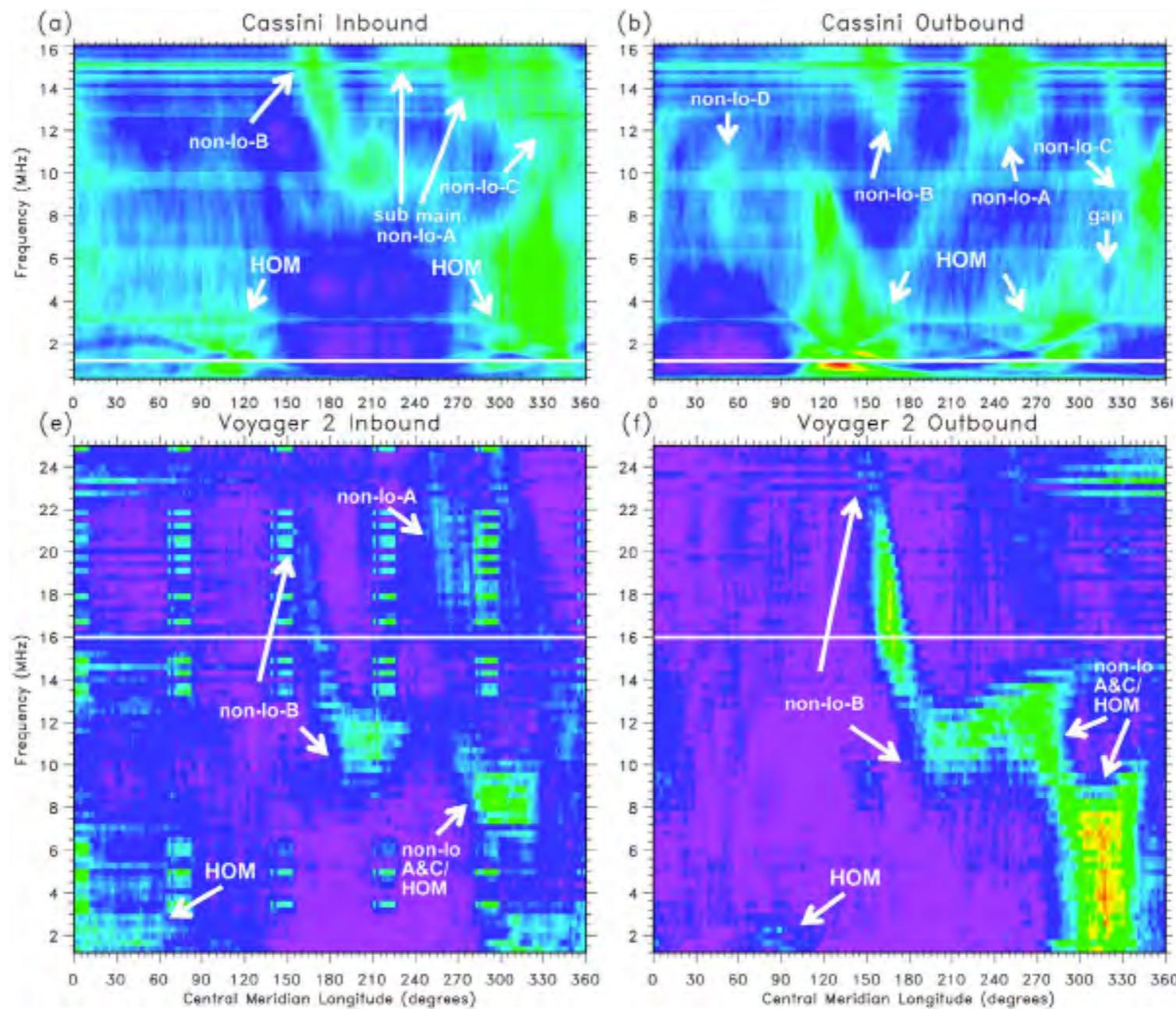
- ExPRES modeling (CMI + geometry + near source refraction) at all latitudes



WORK IN
PROGRESS

What we will do with JUNO

- ExPRES modeling (CMI + geometry + near source refraction) at all latitudes



[Imai et al., 2011]

What we will do with JUNO

- ExPRES modeling (CMI + geometry + near source refraction) at all latitudes
Parametric study → Source locations

Relations between bKOM / HOM / non-*Io* DAM (QP ? nKOM)

Radio beaming & electrons energy

Satellite-Jupiter lead angle ⇒ Unipolar/Dipolar interaction

Relation with UV/IR auroral components ?

- HOM & bKOM as a SW proxy
- Auroral activity → Jovian plasma (sub)corotation ?
- Importance of support Ground-Based DAM observations *[cf. Baptiste's talk]*
→ Cross-correlation (interferometric) measurements WAVES-Ground ?
- Importance of a « perfect » internal B-field model for ExPRES
of a reliable plasma model for ExPRES & ray-tracing (ARTEMIS-P)